Northern fur seal foraging – linking biophysical processes and fur seal behavior to demography

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Alaska Fisheries Science Center

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Management status

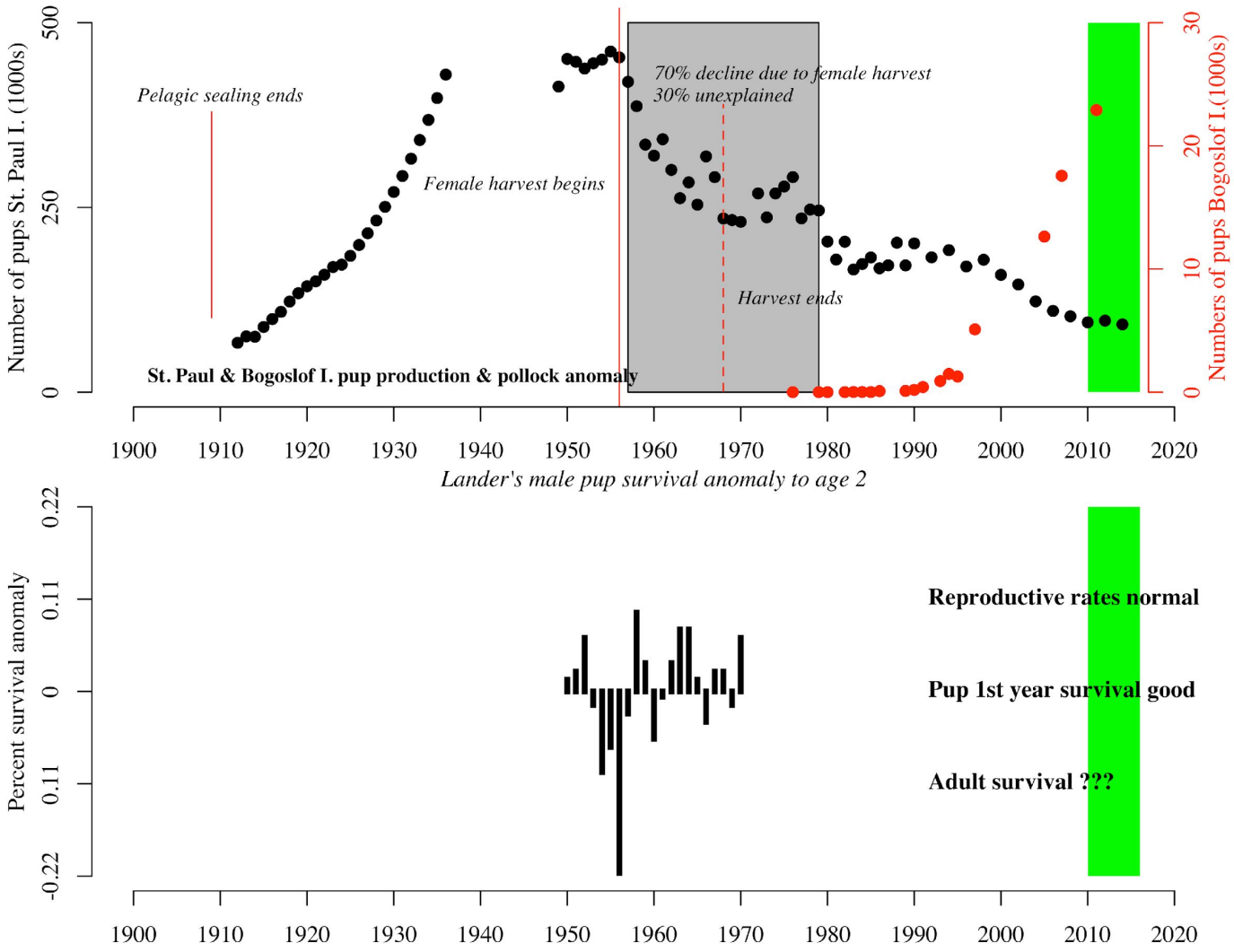
- Listed as depleted under the Marine Mammal Protection Act
  1. Eastern Stock population is ~ 622,908 seals (~ 1/3 of of its historical peak)
  2. Well below OSP (optimum sustainable population)
  3. To be delisted, population needs to double to achieve 60% of historical K

- Determine factors influencing demography as outlined in the Northern Fur Seal Conservation Action Narrative in the 2007 Conservation Plan
  1. Compile and evaluate available habitat-use data
  2. Compile and evaluate existing physical environmental data
  3. Select appropriate environmental indices
  4. Quantify environmental effect on behavior and productivity
  5. Ecosystem modeling
  6. Conduct oceanographic and fishery surveys based on pelagic fur seal habitat use

Objective

- Identify factors influencing northern fur seal demography (Eastern Stock)
  1. Pup production (~1950-2014)
  2. Lander's estimates of male pup survival to age 2 (1950-1970)
  3. Current AEP northern fur seal demography (2010-2015)
- Our hypotheses focus on bottom up processes in both summer and winter
  1. Summer foraging and pup provisioning
  2. Winter migration

Northern fur seal demography



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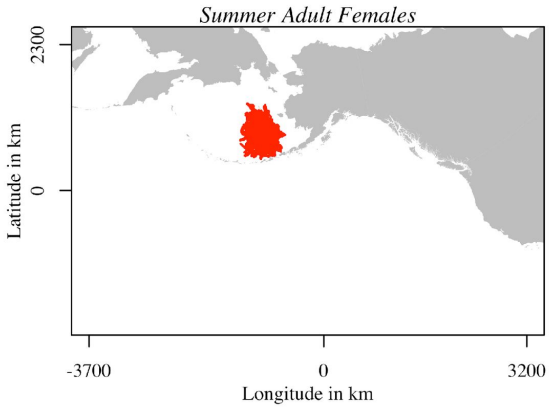
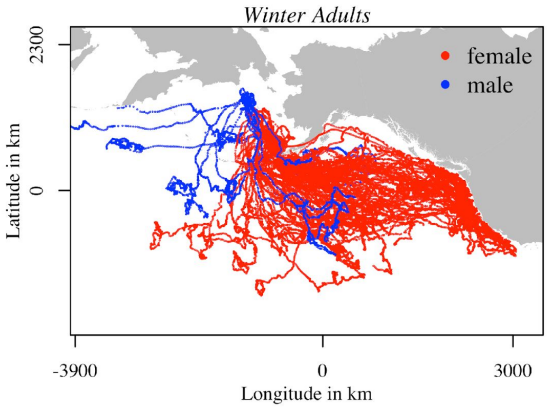
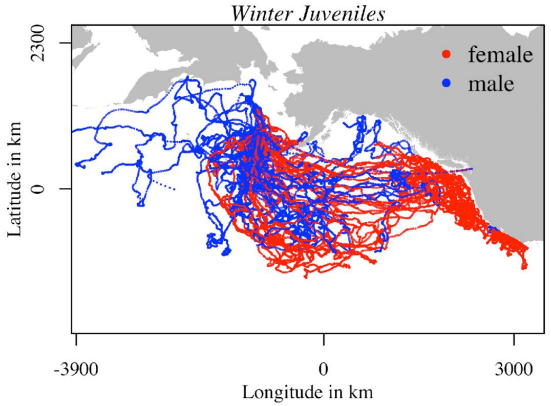
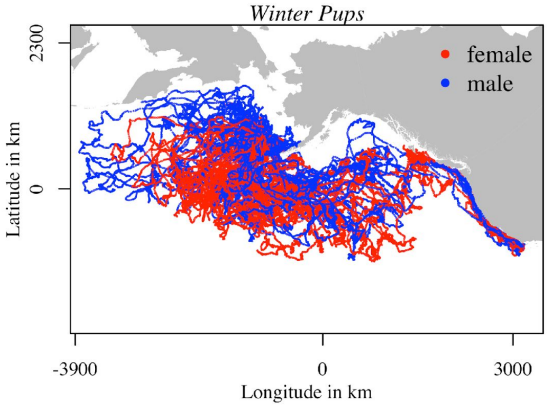
Annual Cycle









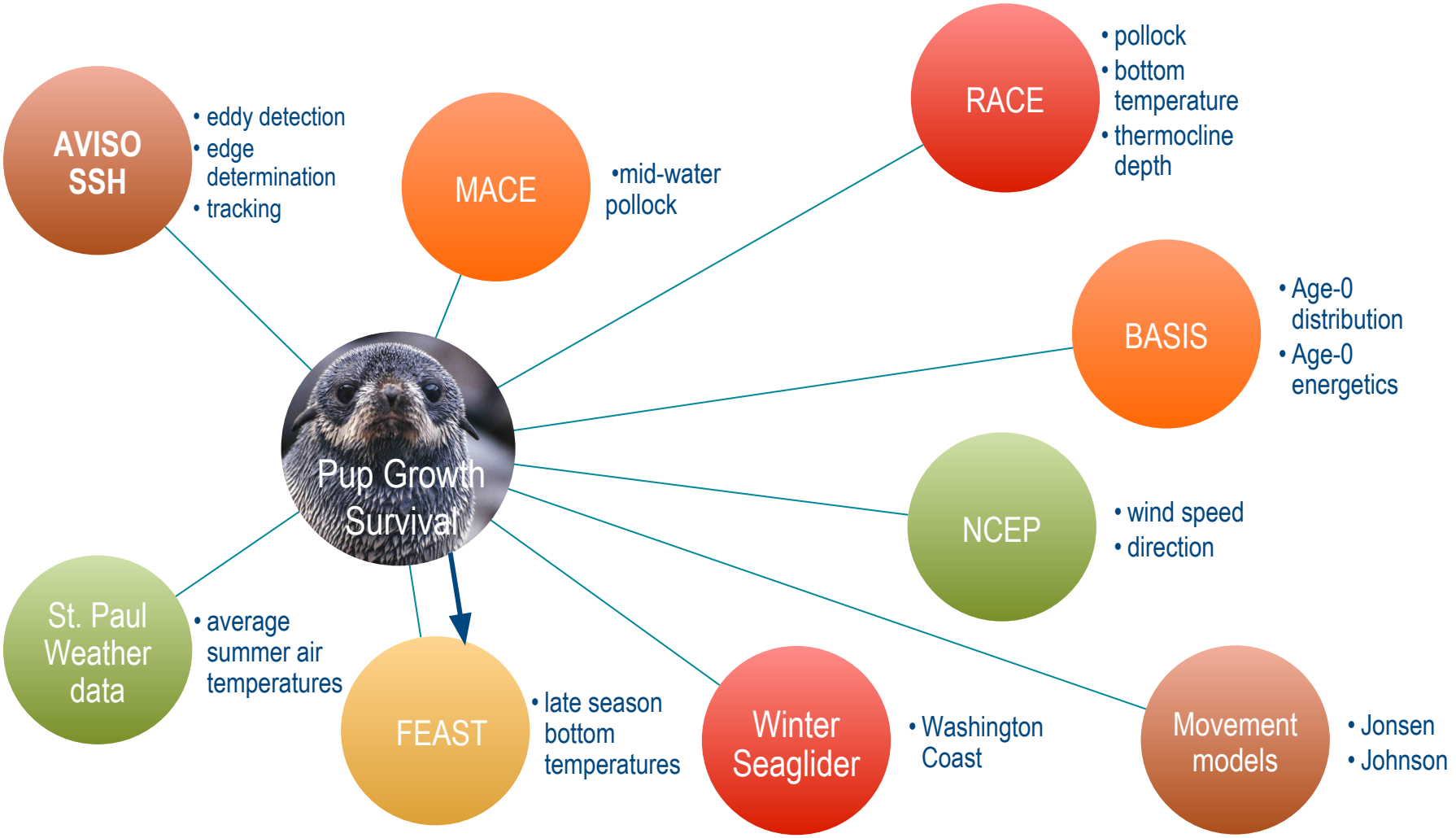
Status of Ecosystem Data – TOR4

- Archived in a SQL database
  1. Telemetry
  2. Diet
  3. Demography
  4. Blood and disease sampling
- Recent and future publications, historical data
  1. Data released with publications under the guidance of NOAA's plan for Public Access to Research Results

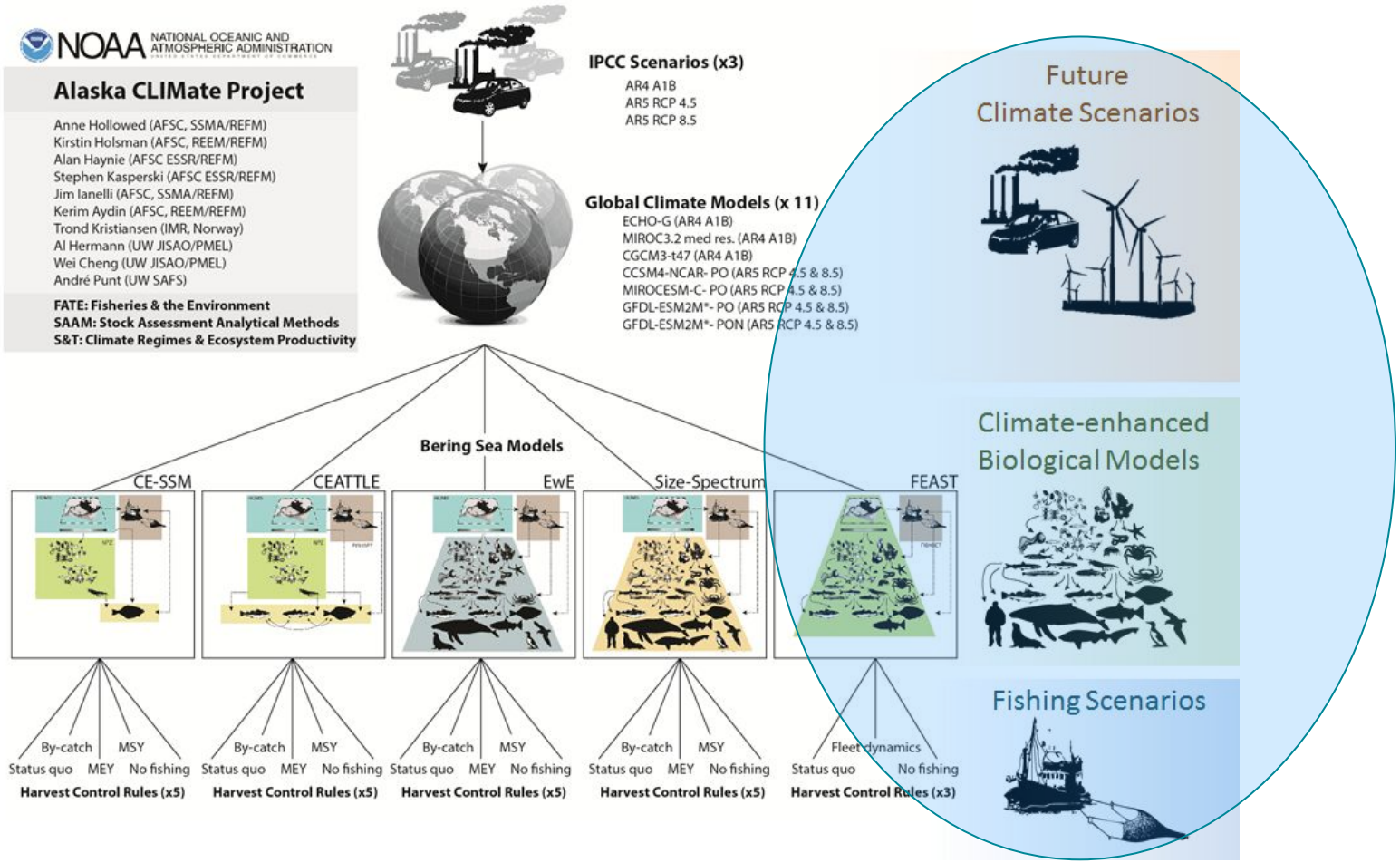
Strategies to obtain and manage ecosystem data – TOR 4

- Looking back to inform future study design and hypotheses (1880-2015)
  1. Data rescue
     - Roger Gentry's behavioral observation archive (1973-1992)
     - Mike Goebel's PhD thesis (1995-1996)
     - Jason Baker's Pup migration study (1996-1997)
  2. Telemetry – Alaska Ecosystem Program has satellite tagged 816 northern fur seals (1992-2015)
     - Adult males and females, juveniles, pups
     - At all Eastern Stock locations
     - Half in the winter, half in the summer
  3. Saildrone survey of fur seal foraging hotspots in the Bering Sea
     - Autonomous oceanographic and acoustic sampling of fur seal prey fields
     - Bottom trawl, mid-water survey, and BASIS survey

Strategies to obtain and manage ecosystem data – TOR 4



Status of ecosystem modeling – TOR 5



Integrated ecosystem-level analyses – TOR 5

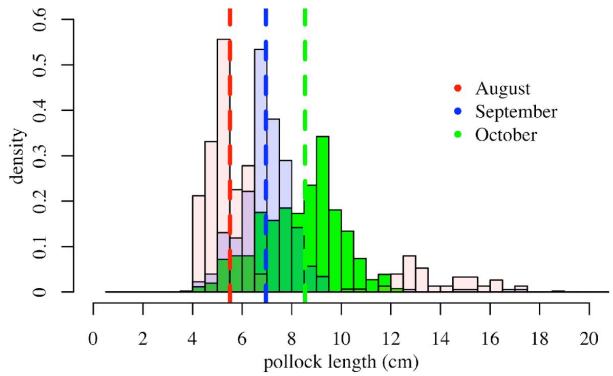
- Migration, diet, and oceanography of adult females (Ream et al. 2005)
- Dispersal patterns of pups and climate (Lea et al. 2009)
- Subsurface thermal structure and the influence on adult female dive behavior (Kuhn et al. 2010)
- Local depletion and foraging patterns of Bogoslof adult females (Kuhn et al. 2014)
- Adult male and female migration patterns and the influence of the thermocline, storms, eddies, LME, and light (Sterling et al. 2014)
- Adult female migration in the California Current – foraging patterns explained by Seaglider observations (Pelland et al. 2014)

Integrated ecosystem-level analyses – TOR 5

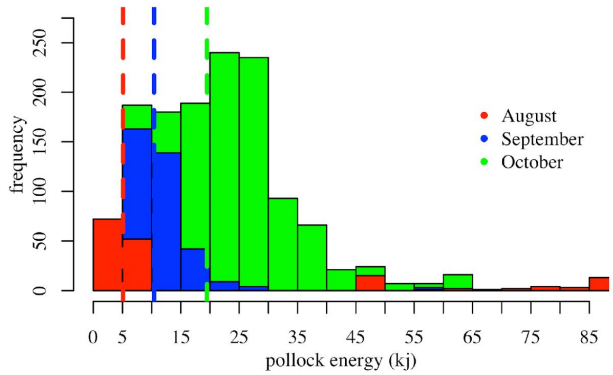
- Fur seal foraging and pup provisioning – responses to basin dynamics, storms, pollock stock structure, distribution and abundance
  1. Benefit from Bering Sea Project results and integrate with fur seal foraging
- FEAST
  1. Energetics adult females
  2. Diet
- Saildrone Project 2016

Fur Seal Diet – Energetics

August, September, October pollock length frequencies



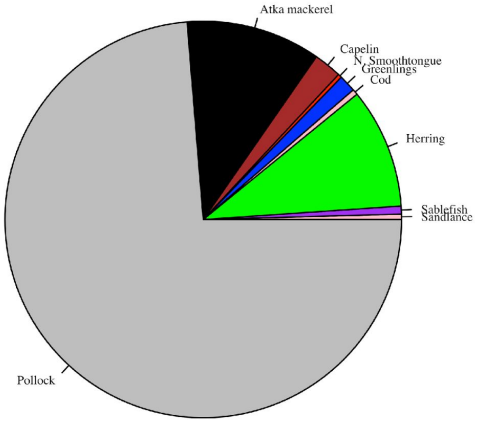
August, September, October pollock energy in kilojoules



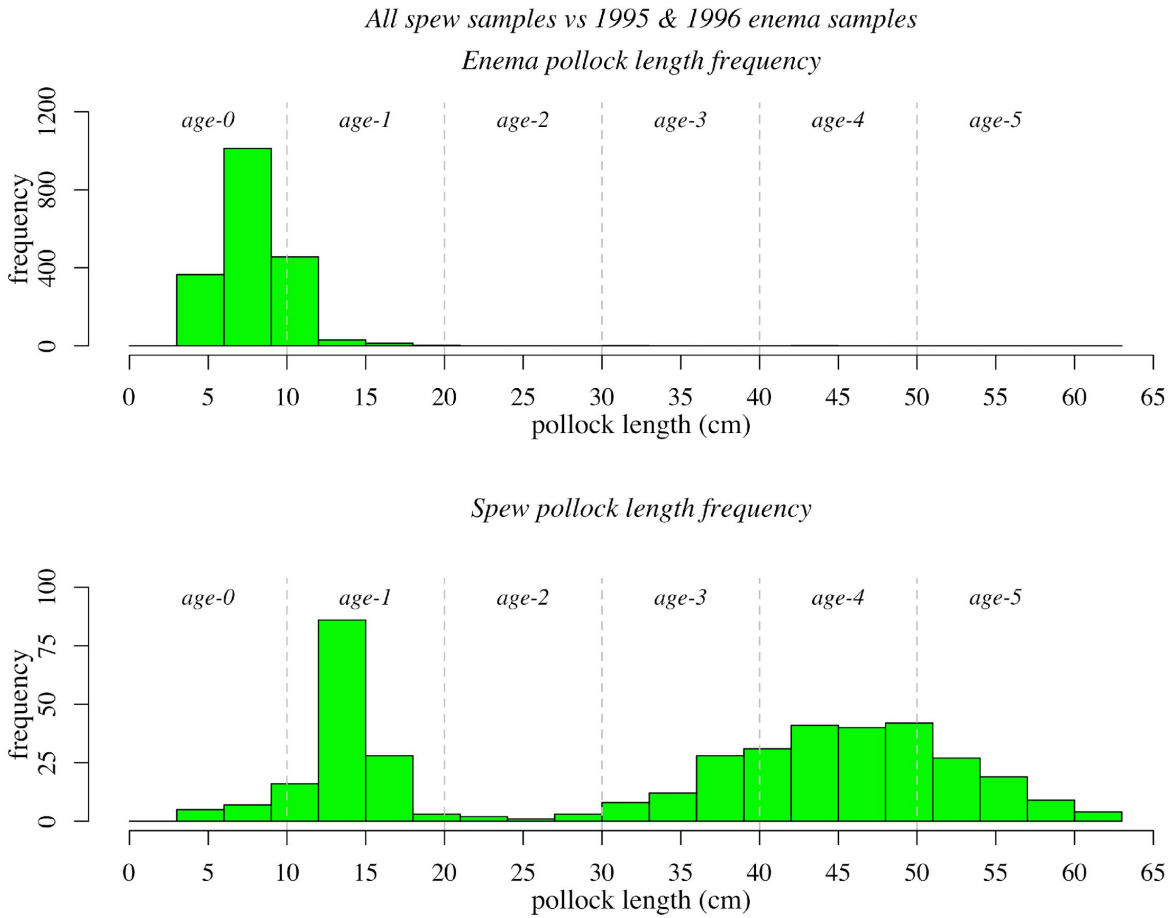
1996 Enema Results

n = 64 seals and 1,986 fish

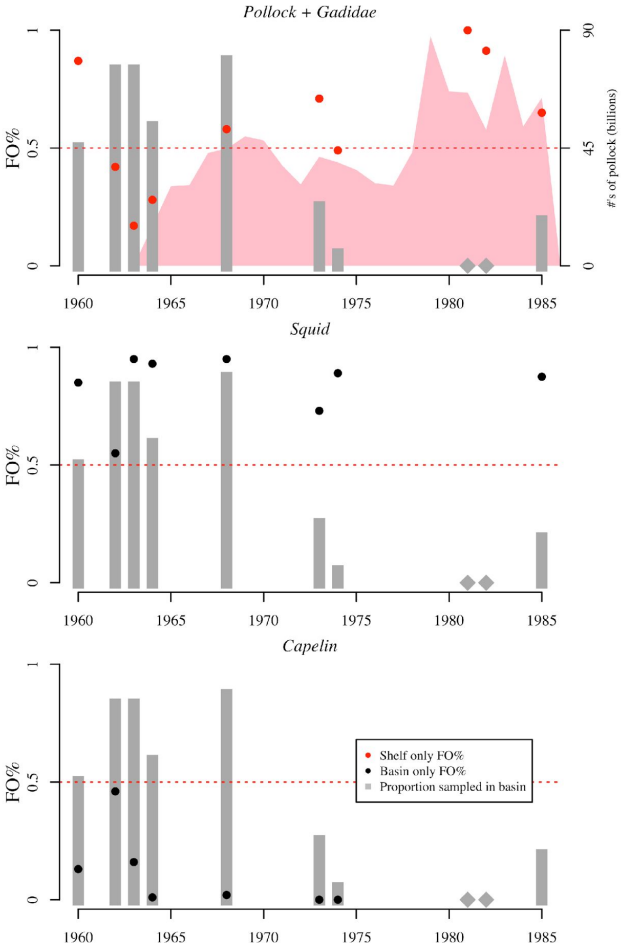
Enema prey energy content - Total = 22,498 kj

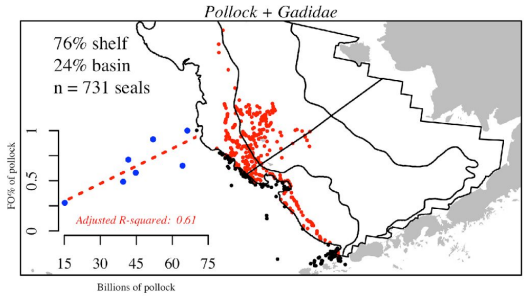


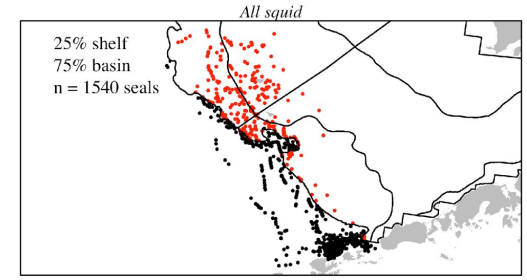
Diet – pollock age structure by sample type

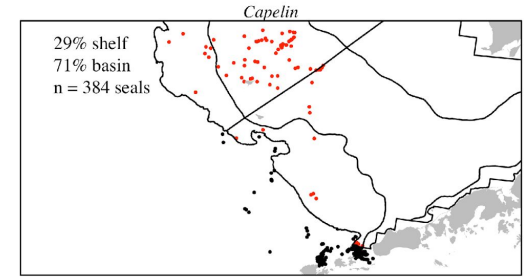


Diet – spatial





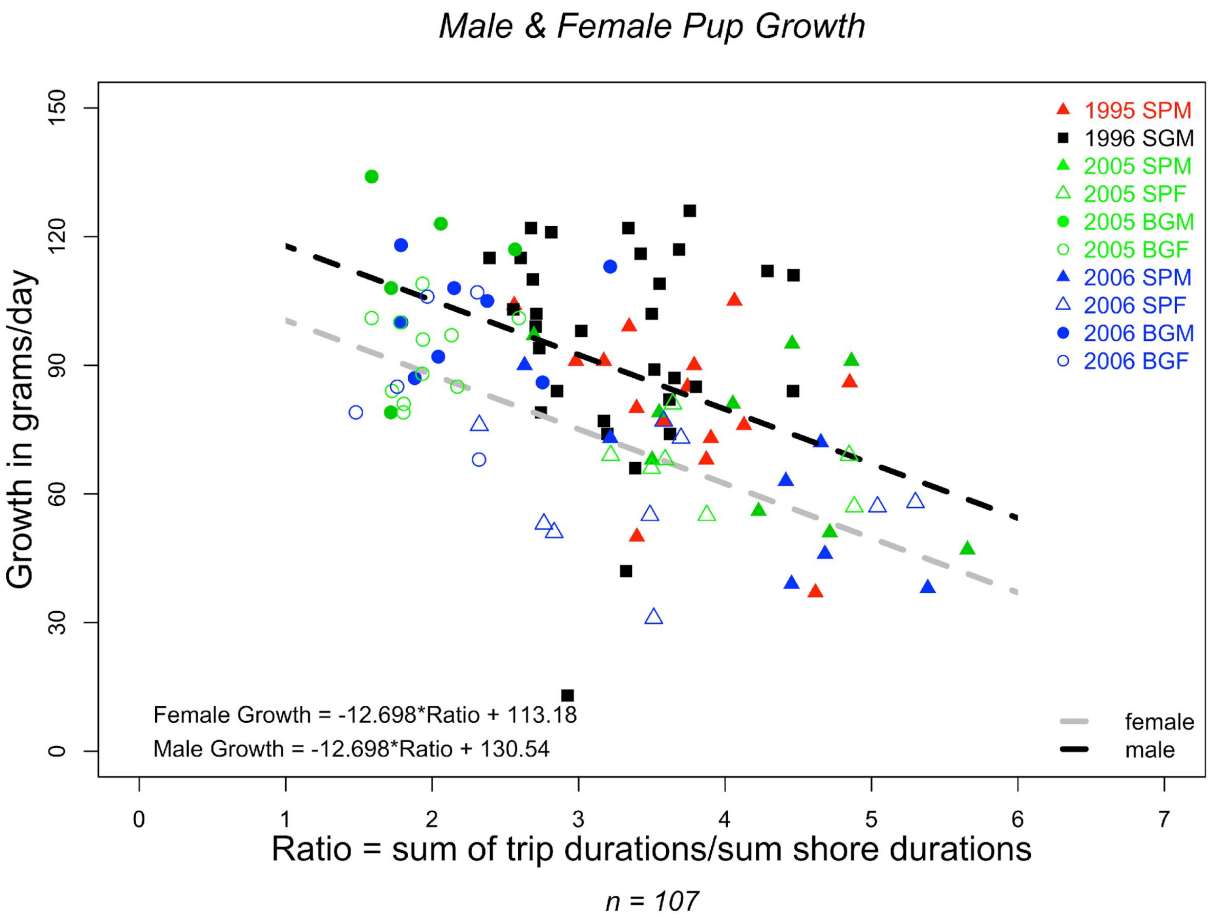




Pup provisioning – 2 Studies (Goebel & COFFS)

Pup Growth

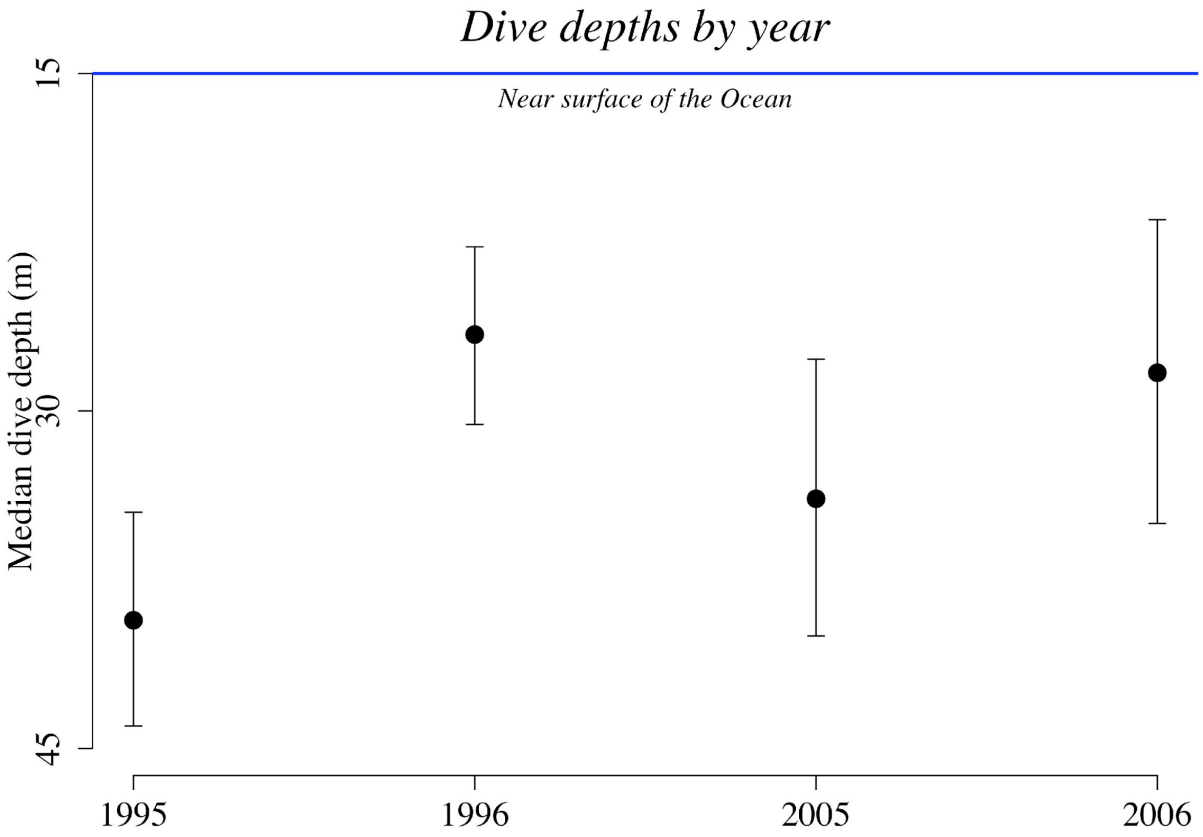
Mom behavior and pup growth



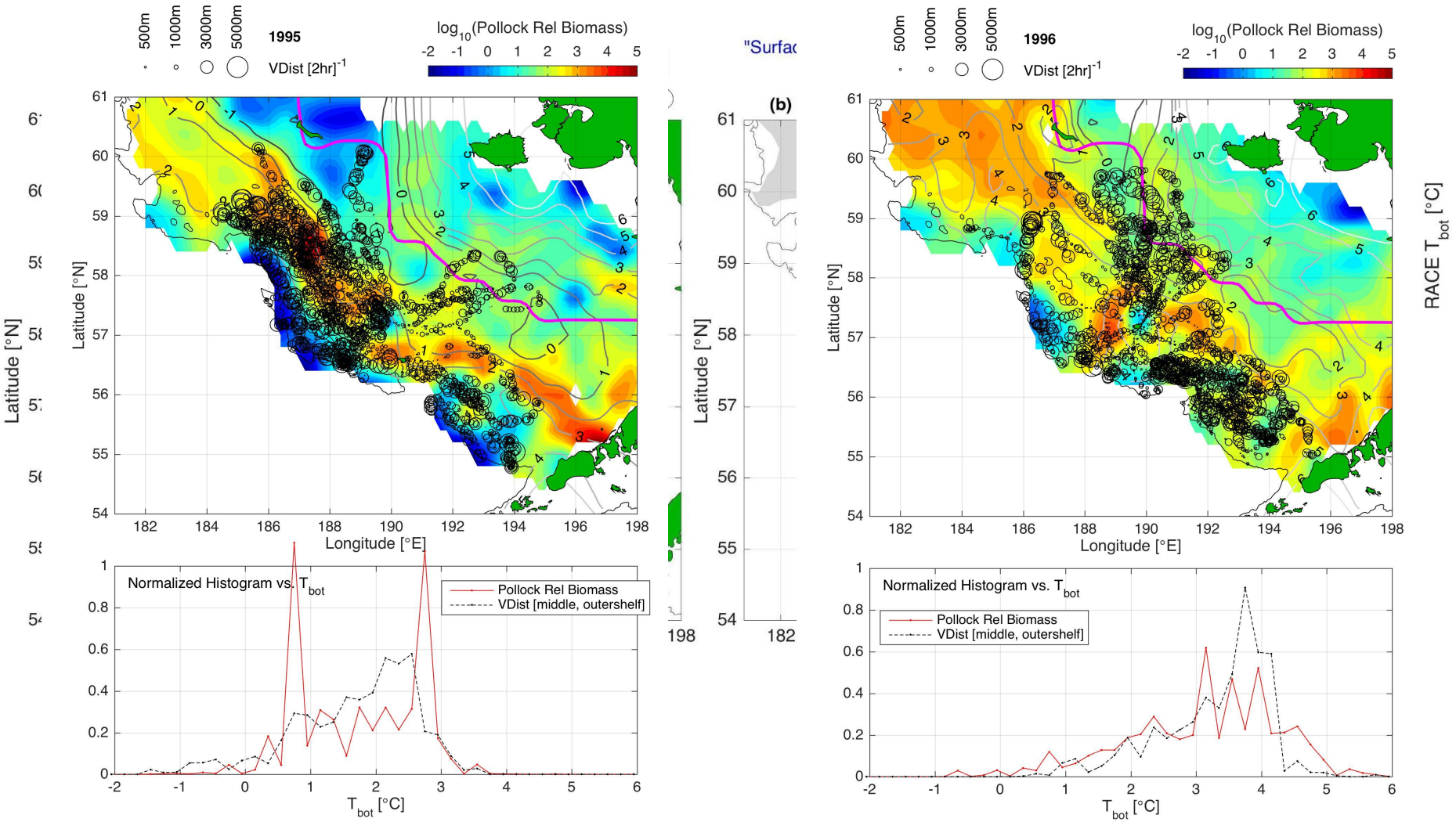
Eddy variability

1996 2006 Eddies

Shelf foraging – diving



Shelf foraging – cold vs. warm



Storms

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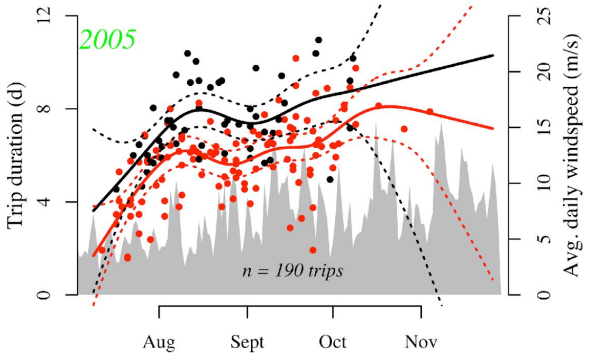
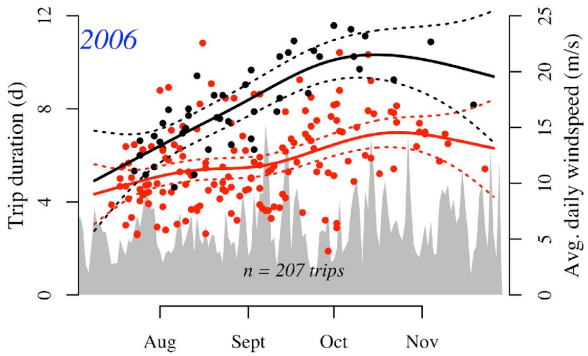
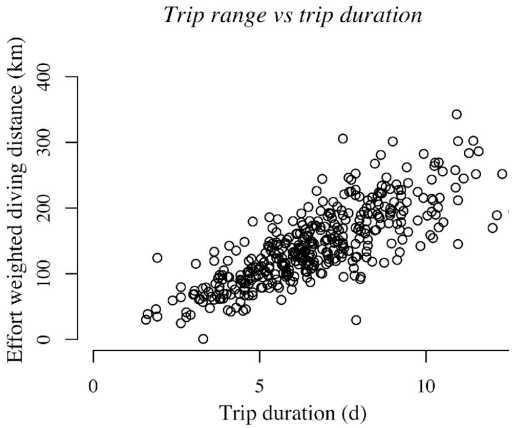
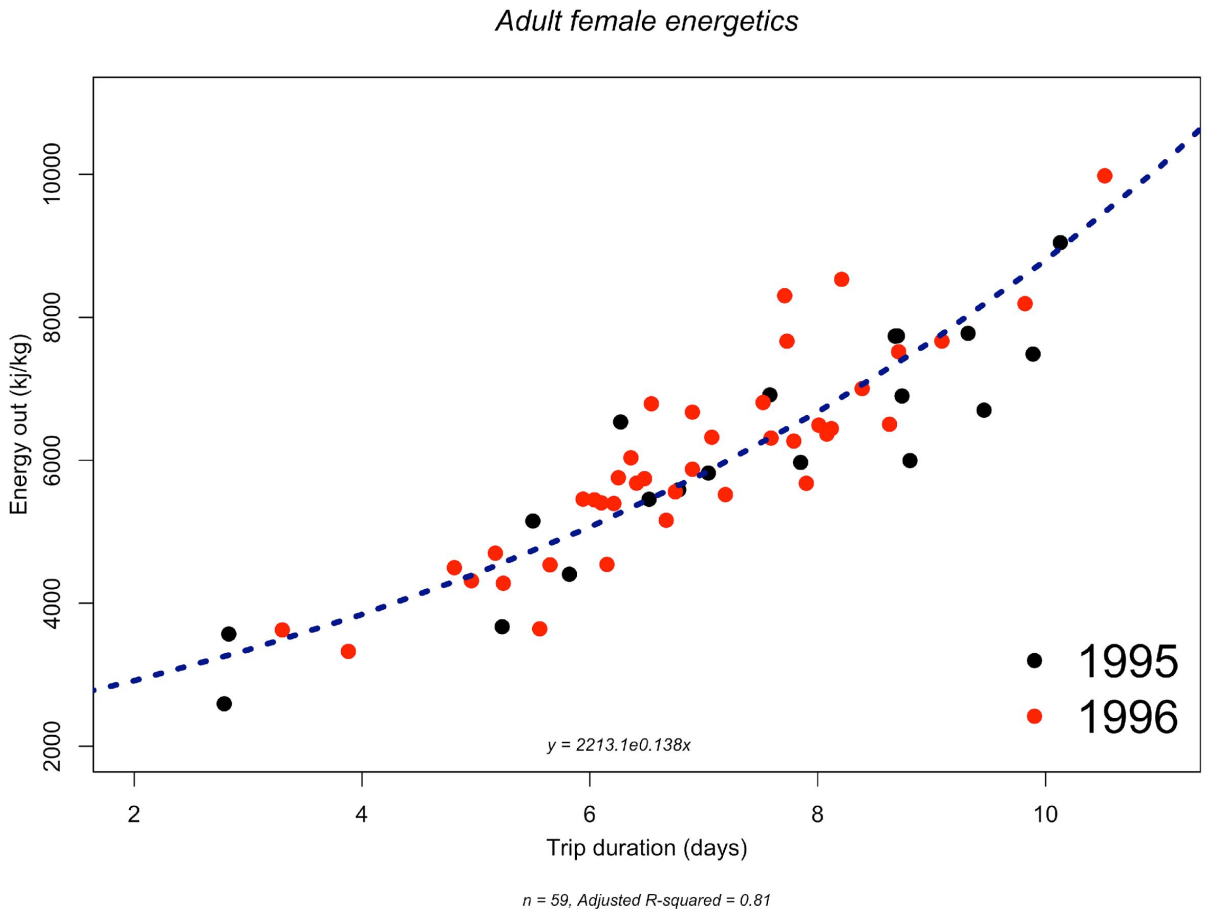






FEAST – unpublished fur seal energetics data

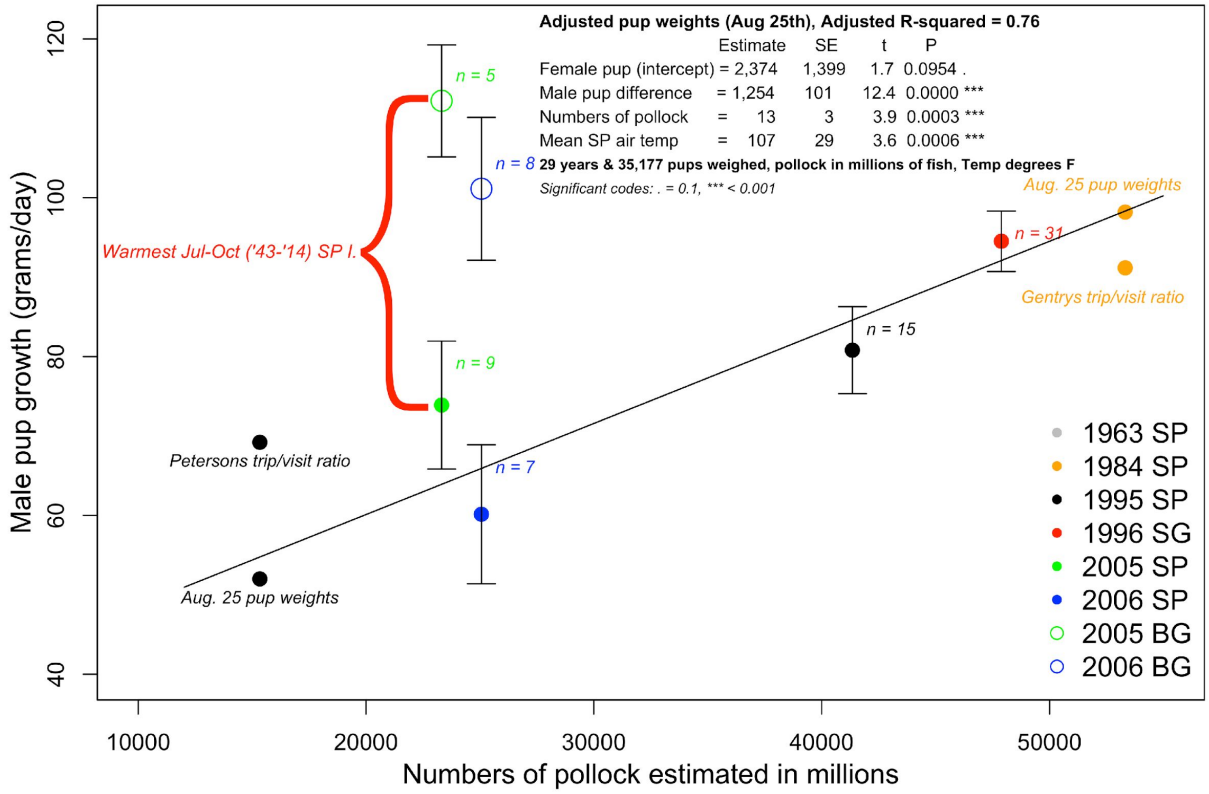


Cumulative analyses – TORR 5

- Identify both summer and winter indices to explain current and past demography
  1. Numbers of pollock from stock assessment (summer)
  2. Eddy variability (summer and winter)
  3. Winter storms and mesoscale currents (winter)
- Use statistical relationships and model coefficients for inputs into climate change projections

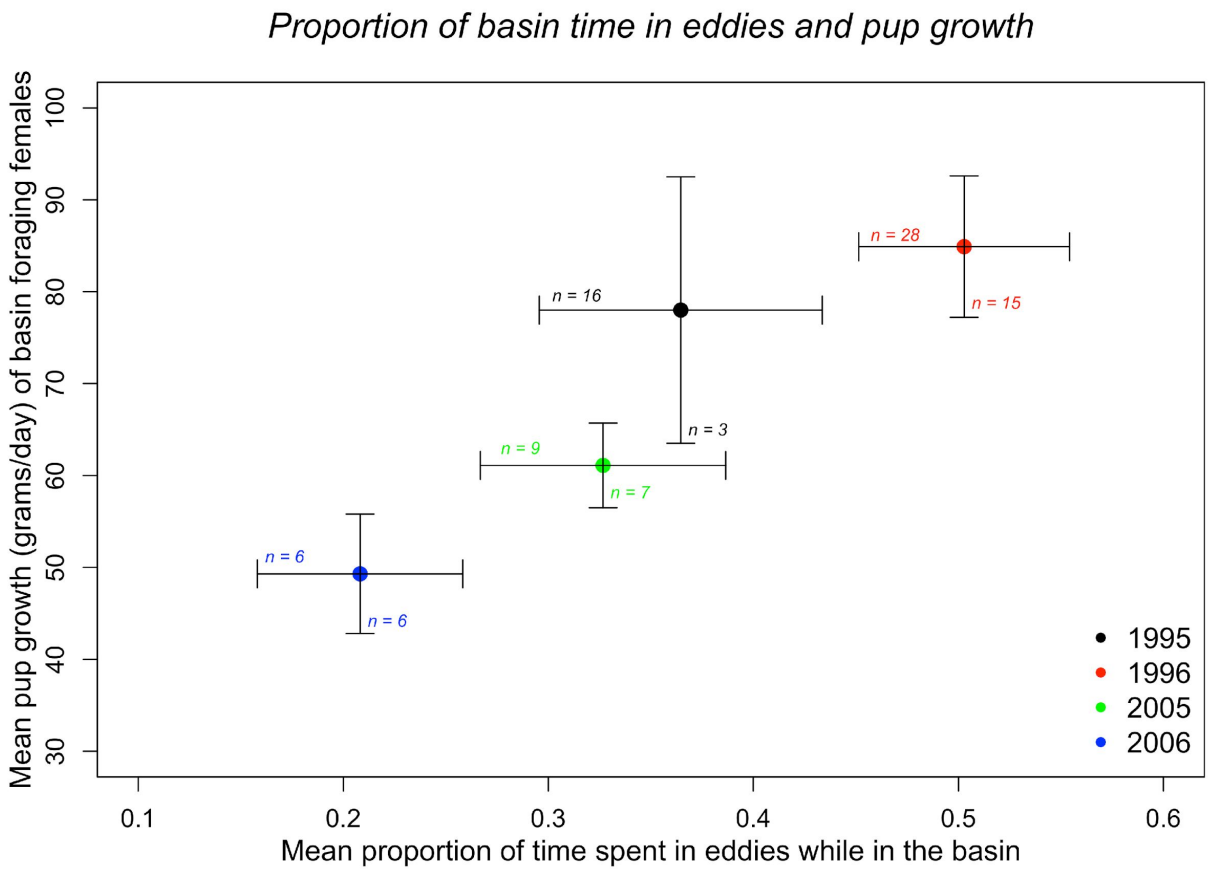
Pup growth and linkages to pollock

Male pup growth & M/F pup weights



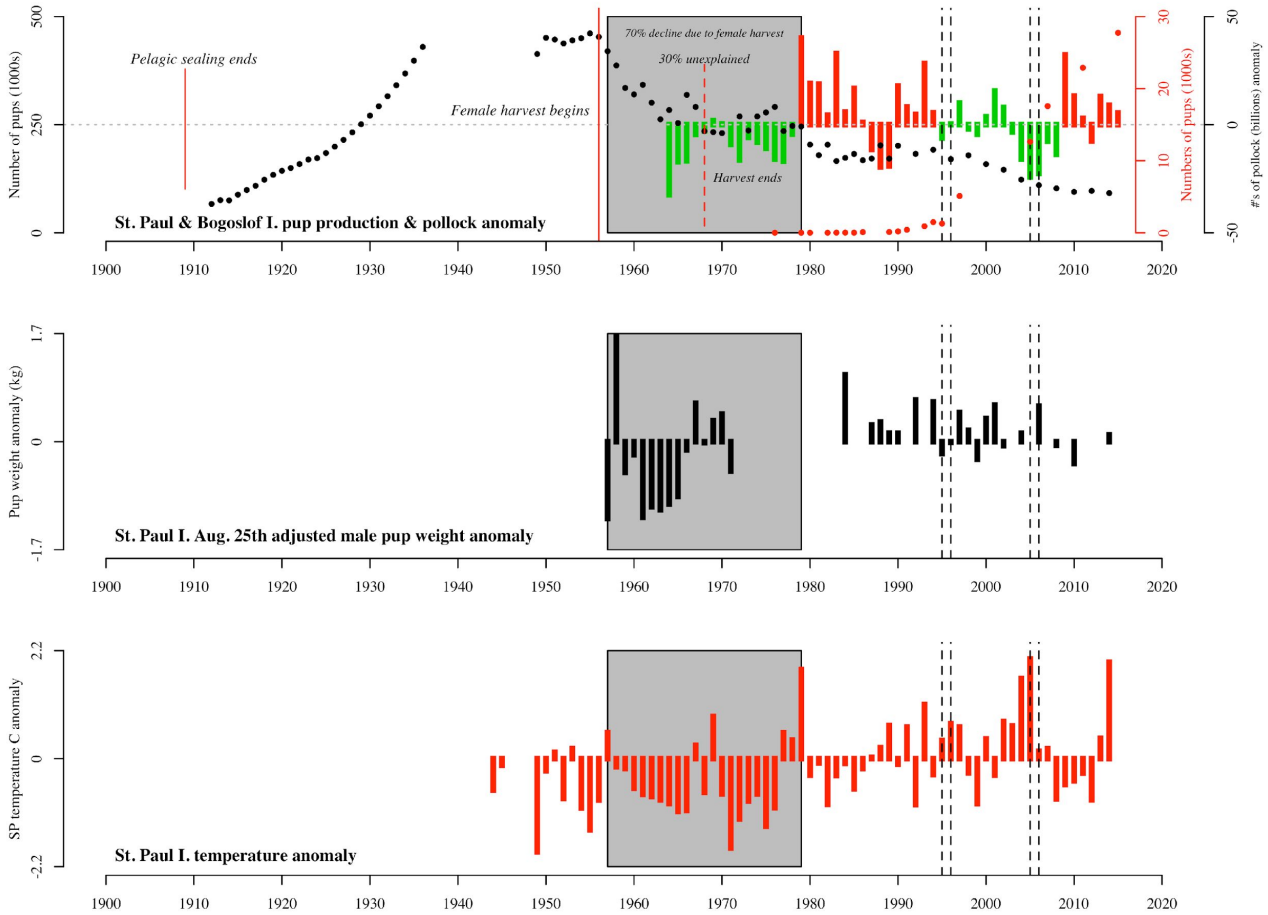
Linear model fitted to '63 & '84 est. growth from pup weights & '95,'96,'05,'06 Pribilof pup growth from study animals

Pup growth and time in eddies



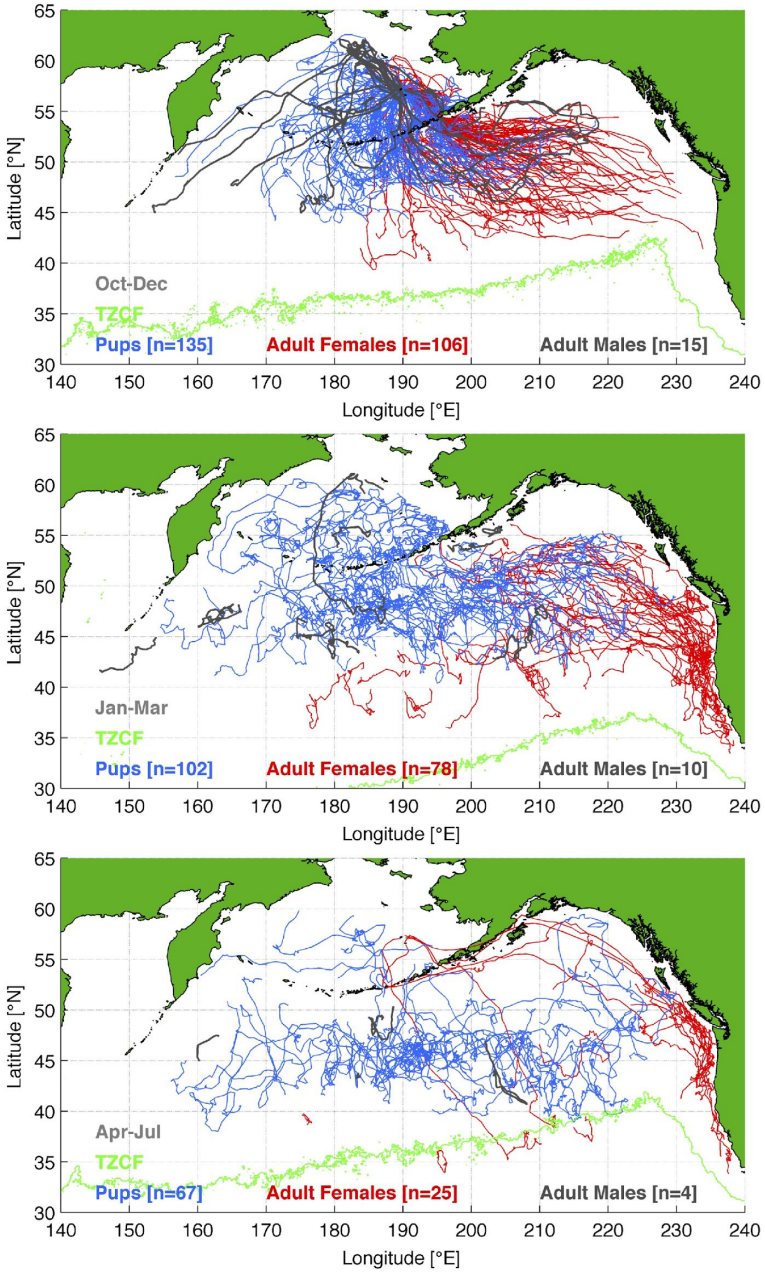
Female pups included in 2005 & 2006 - no difference in basin M/F pup growth

Potential links to productivity

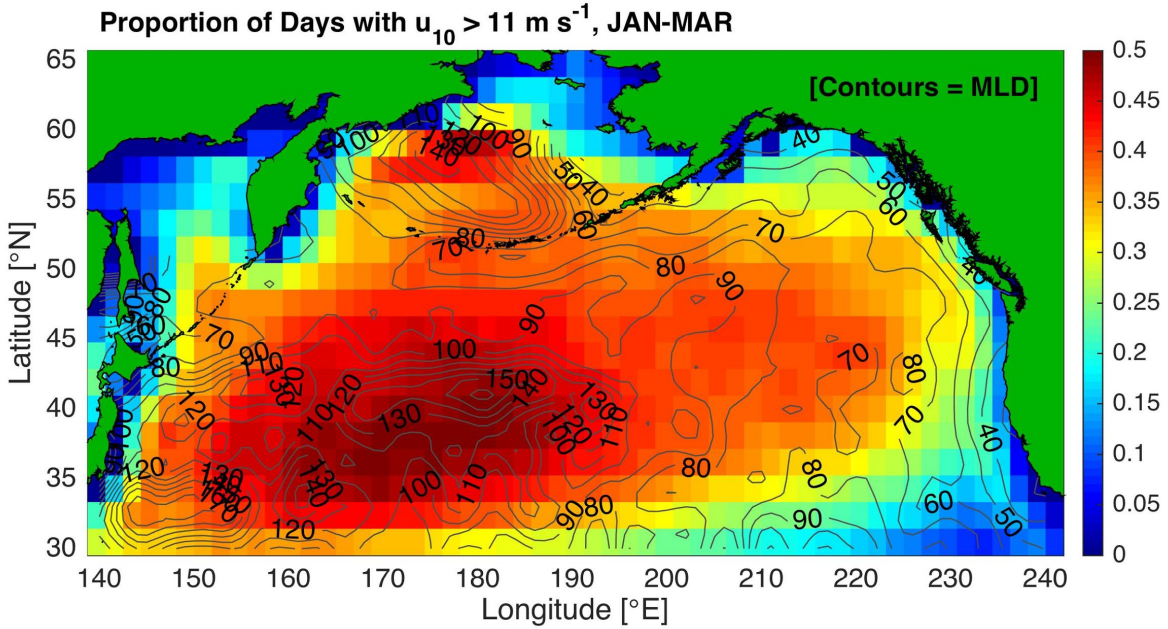


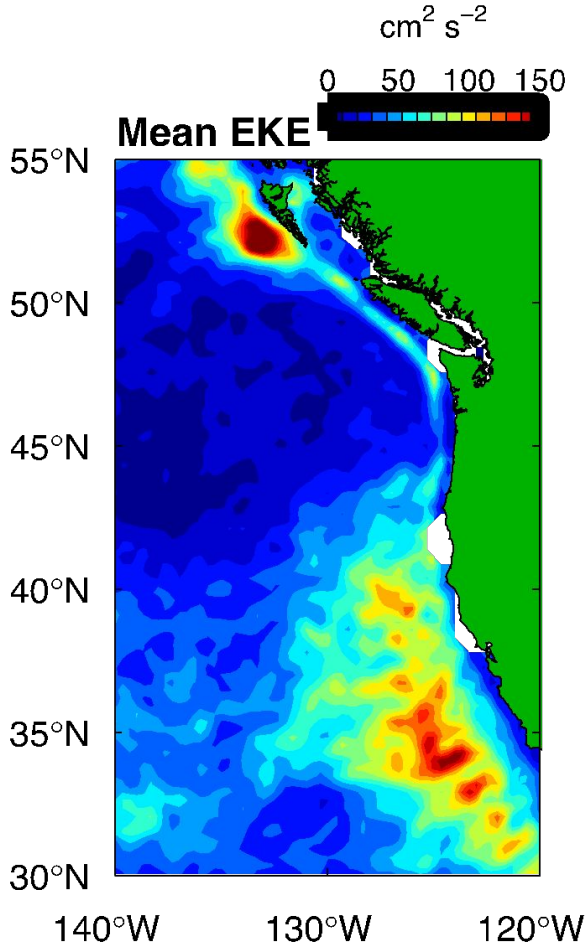
Winter Migration

- For Eastern Pacific Stock, migration begins Oct-Nov, ends May-June
- Individuals disperse widely throughout North Pacific
- Different groups face different pressures
- Location estimates, dive data analyzed for 135 pups, 105 adult females, 15 adult males
- Compared to remote sensing, reanalysis, autonomous instruments, animal-borne sensors

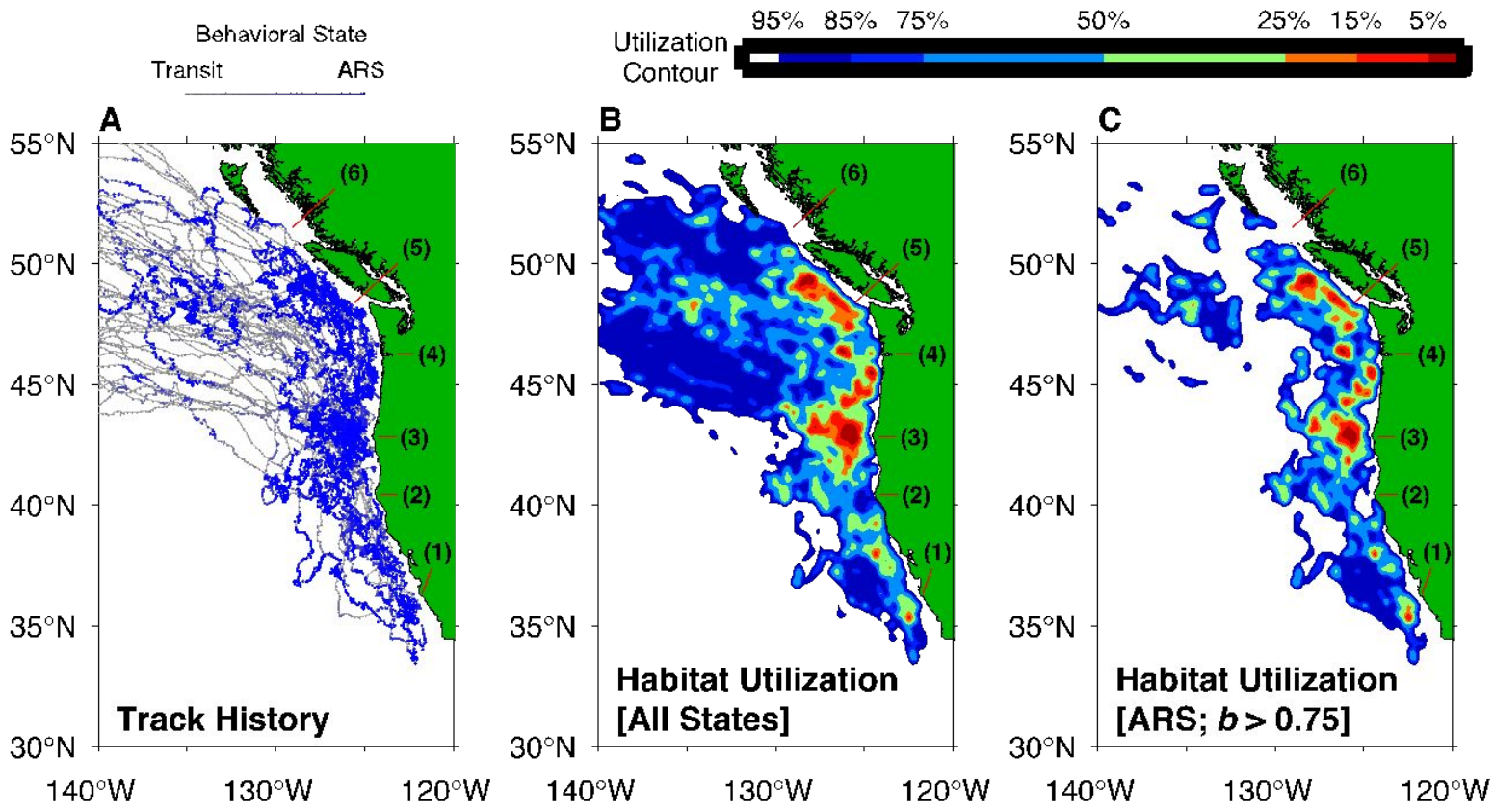


- Migratory habitat is **segregated by age, sex**
- **Adult females:** North American Coast (~2/3) and transition zone chlorophyll front (~1/3)
- **Adult males:** wide longitude range, some remain in Bering Sea, but almost never NA Coast
- **Pups:** overlap with both in 1st winter, but mostly adult males

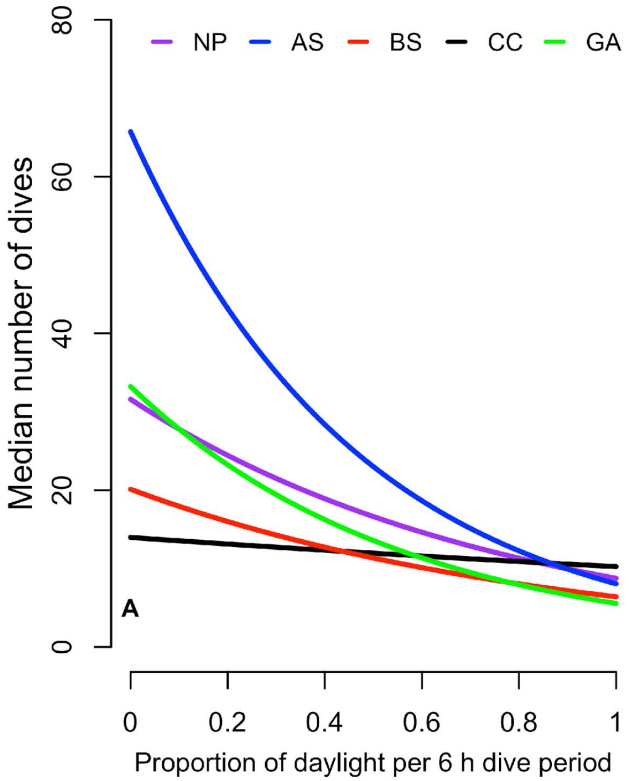


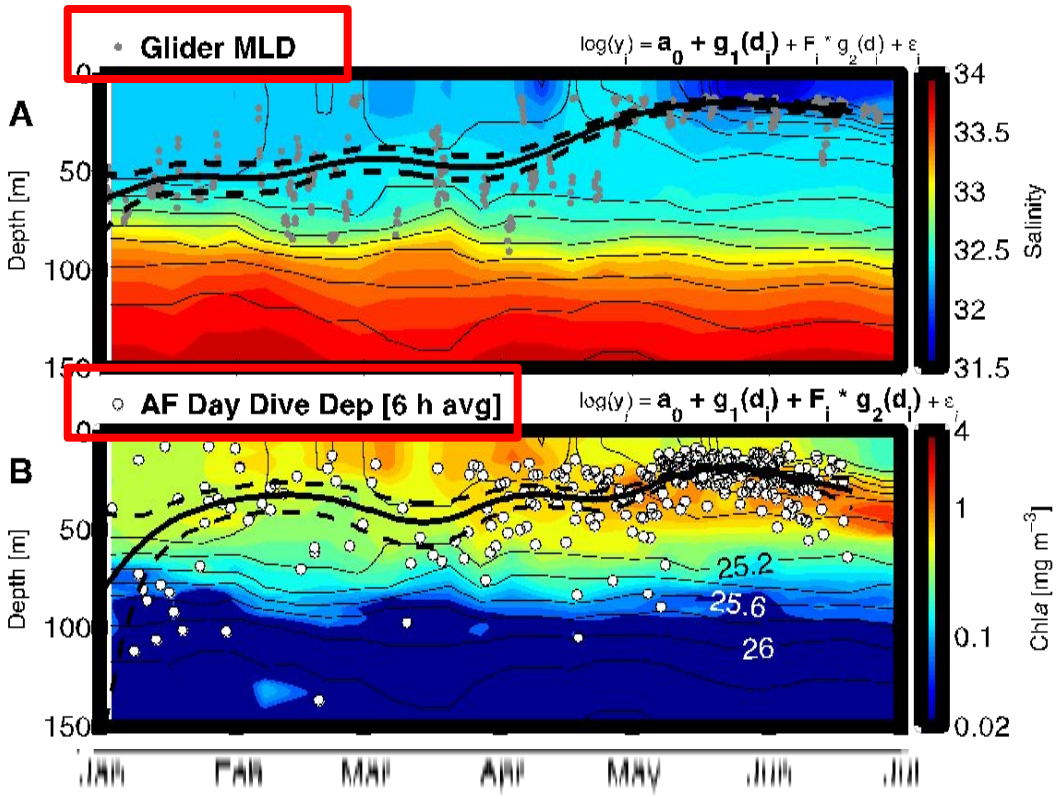


- As a consequence, different groups **must face different environmental conditions**
- Adult males, many pups: frequent high winds, deep surface mixed layer (ML)
- Most females: shallower ML depth, fewer stormy days, upwelling, eddy generation



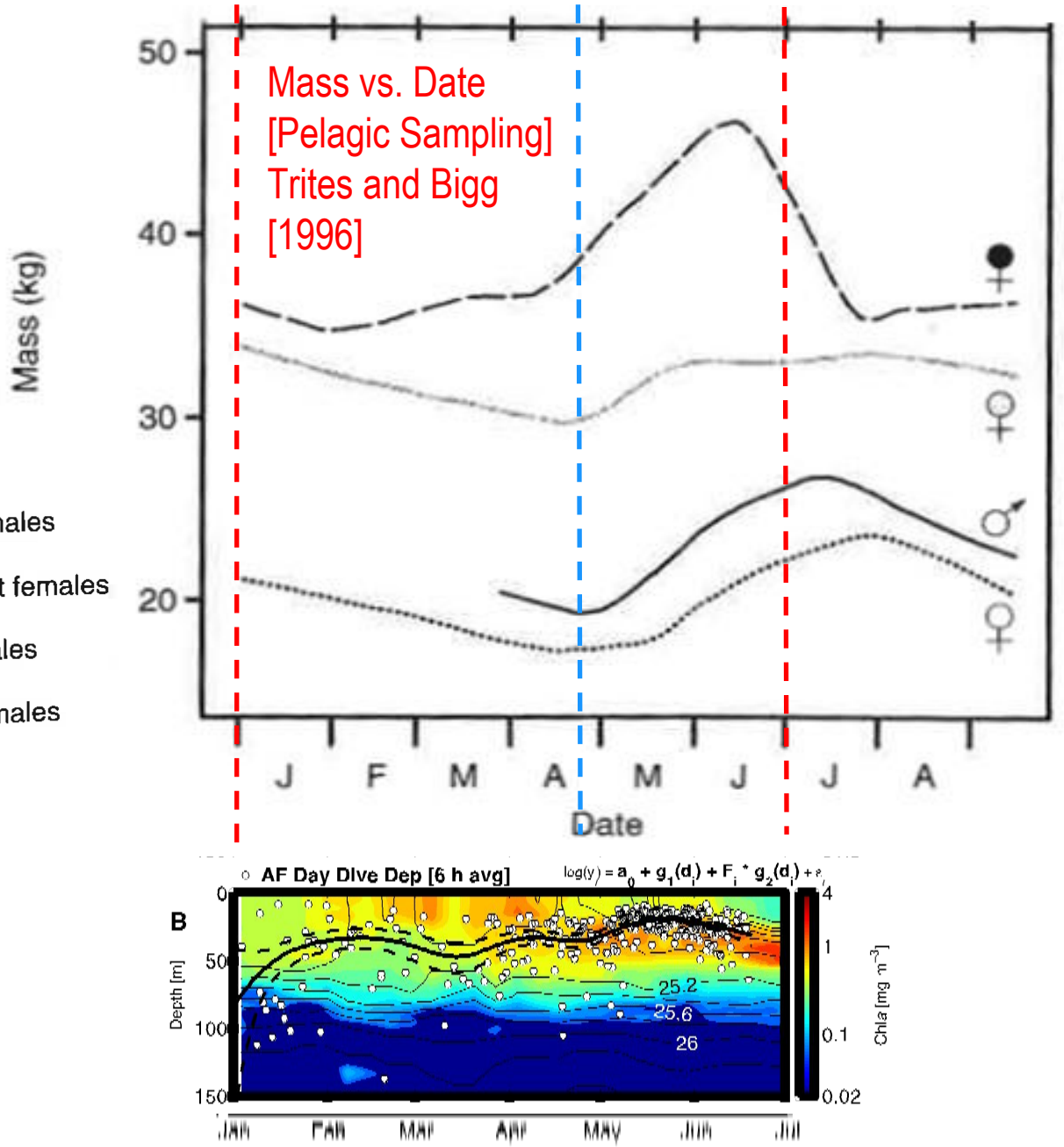
- Subset of females traveling to Gulf of Alaska, California Current
- Use of habitat around coastal capes (esp. Cape Blanco), energetic coastal transition zone
- Some statistical evidence for preferential use of eddies in long tracks





- Females entering the CC **dove proportionally more during daylight**
- Depth of these daylight dives showed correspondence to the MLD

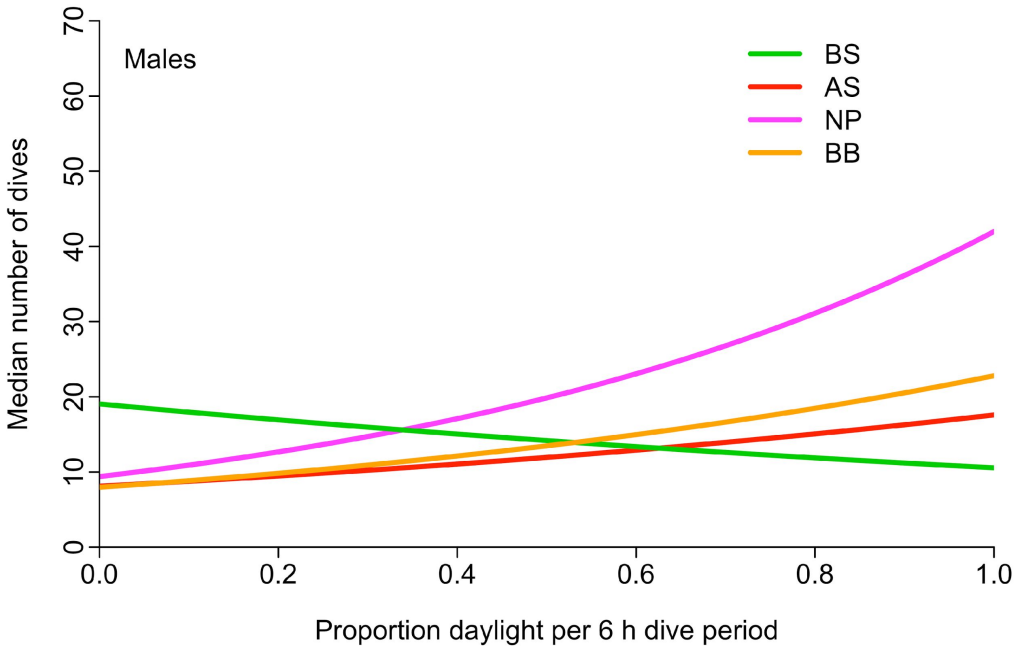
- In pelagic sampling, mass, length increases in adult females, immatures of both sexes began in late April/early May

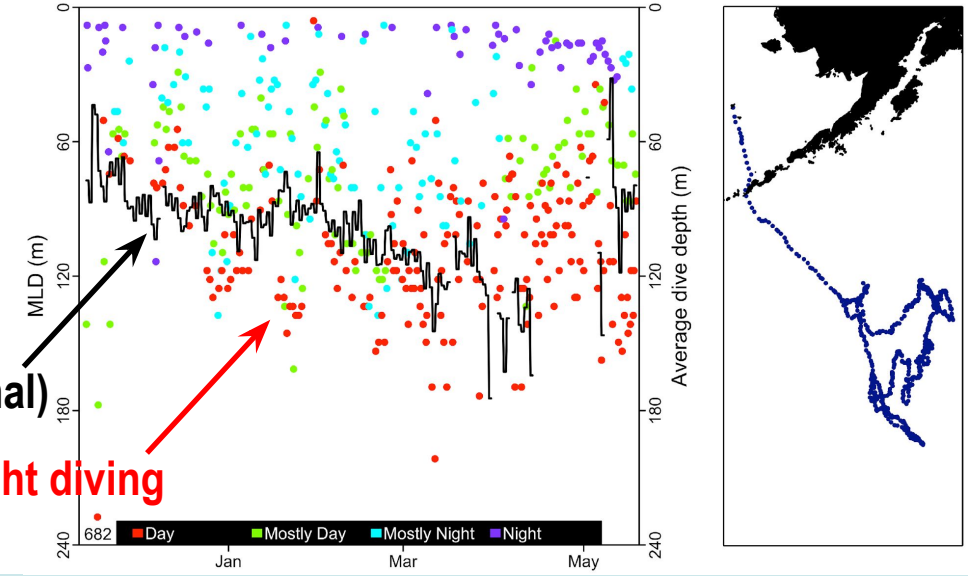


- Changes in daylight diving show similar timing

- Males wintering in central NP exhibited similar behavior
- Implication that upper-ocean **stratification affects the depth of NFS prey fields during daylight**
- Recall males winter where the MLD is deeper (100-125 m vs. 20-75 m)

*"We conclude that adult male NFS winter in the northern NP and Bering Sea because they **can**…Females pursue a different strategy because they **must**."* [Sterling et al., 2014]

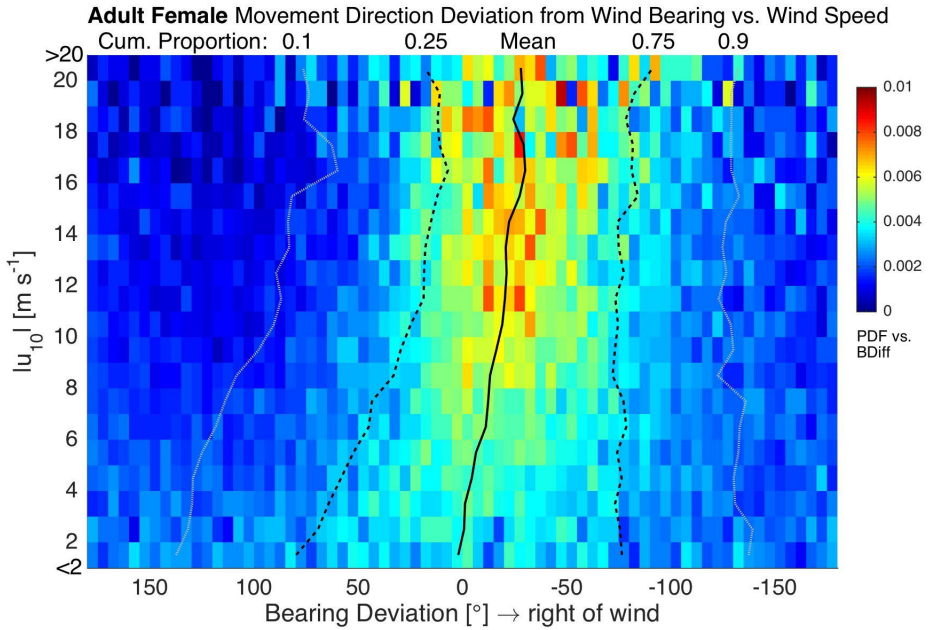


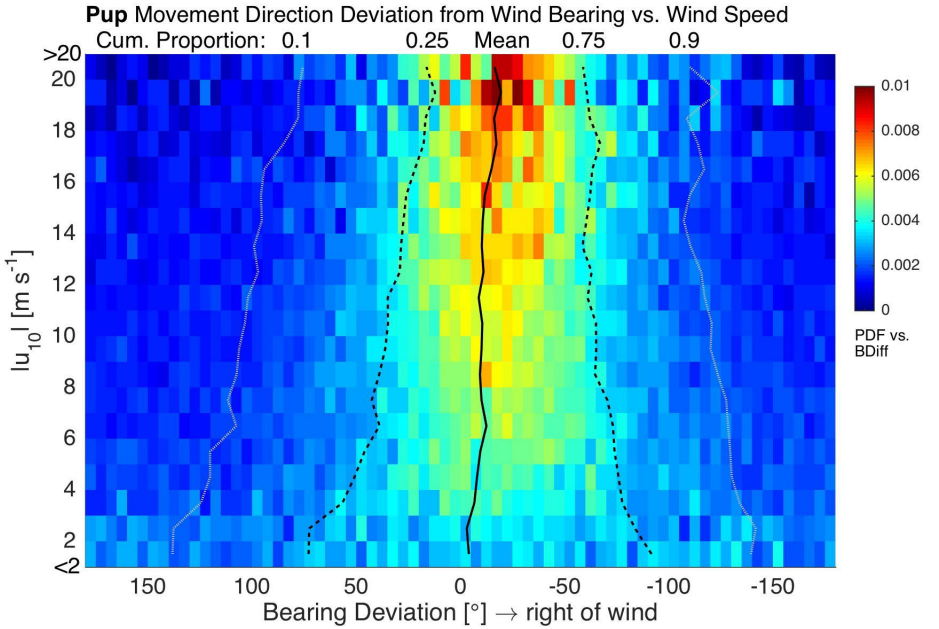


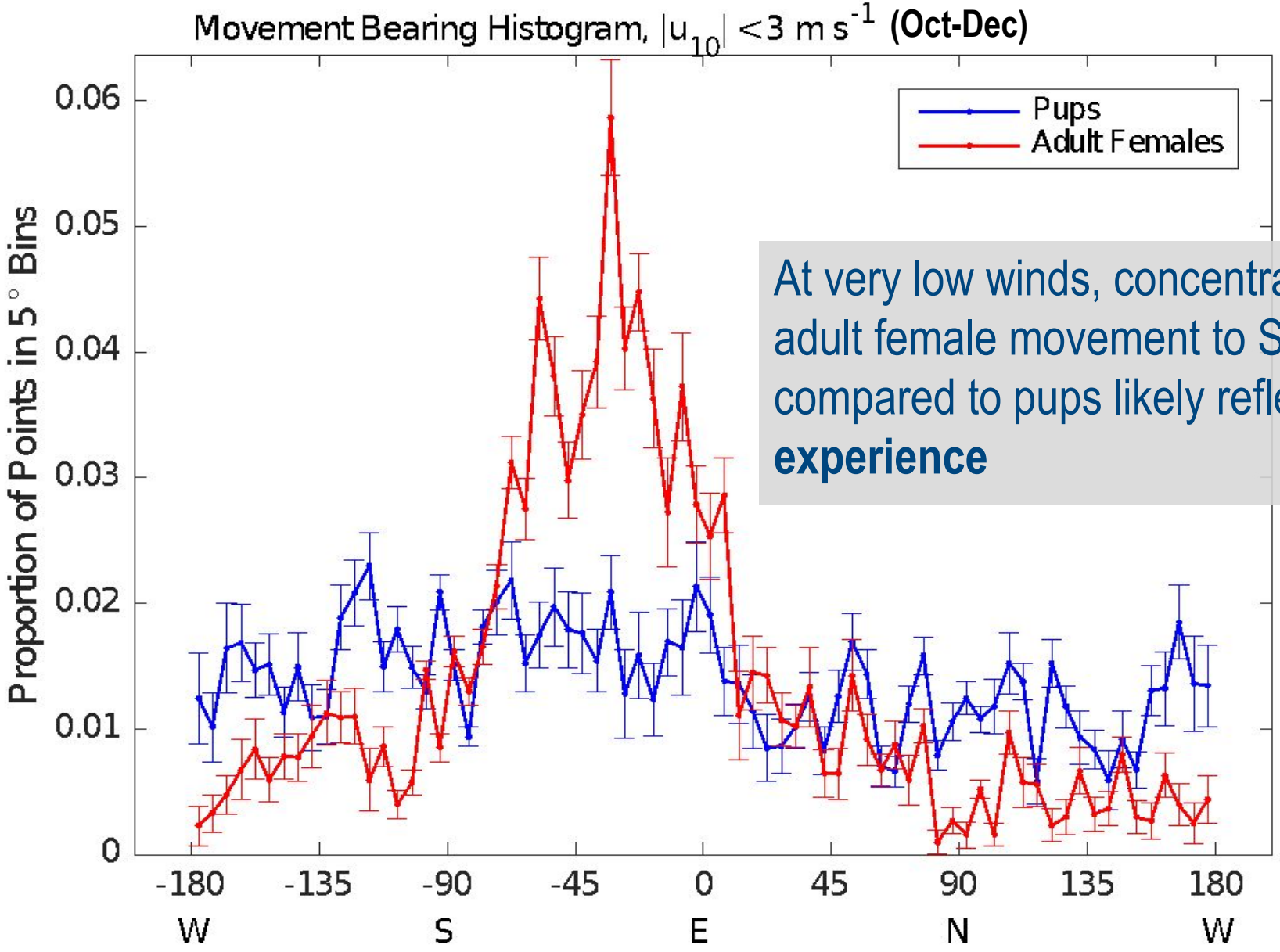
Dispersal and Migratory Movement

Winter storms

- Comparison of “naively-modeled” movement direction to wind direction (6-hrly)
- Wind speed ⇧: distribution of movement bearings more concentrated downwind, and to right
- Physically consistent with surface drift (but too downwind) – implies behavioral component (or sampling…)







At very low winds, concentrated adult female movement to SE compared to pups likely reflects **experience**

Inclusion of ecosystem data into living marine resource management advice – TOR 6

- Provide fur demography results to the Ecosystem Considerations Chapter
- Work closely with the Alaska Regional Office and communicate research results
  1. Annual meeting
  2. Michael Williams
- Implement studies listed in Conservation Action Narrative of the 2007 Conservation Plan for the Eastern Pacific Stock of Northern Fur Seals

Peer-review of ecosystem-related science program and products – TOR 7

- ~ 85 publications peer-reviewed publications since 2000

Communication to managers, partners, stakeholders and the public – TOR 8

- Annual presentations at conferences
  1. Alaska Marine Science Symposium
  2. Marine Mammal Conference
  3. Ocean Sciences
  4. CLIOTOP – Climate Impacts on Oceanic Top Predators
  5. Bio-Logging
  6. Conservation Biology
- Meetings with the Alaska Regional Office
- Partnership with the Seattle Aquarium